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Tall tale: Trees could power wireless networks

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PORTLAND, Ore. — The U.S. Forest Service uses a network of automated stations to track weather conditions, especially during fire season. But the solar-powered remote network needs large forest clearings so the Sun can reach collectors.

At the same time, Forest Service officials wish they could install sensors on more trees.

Now, researchers say that by harnessing the voltage difference between a tree and the ground new ultralow-power sensors can transmit sensor data from almost any tree. The approach would also elimate the need to clear the forest floor for solar power.

"We believe that by installing wireless sensors on just four trees per acre, we can provide better fire prediction modeling, earlier alerts and much better local climate data than is available in any forest today," said professor Andreas Mershin of the Massachusetts Institute of Technology.

MIT researchers also predicted that tree power will eventually be useful for other types of environmental monitoring, such as watching the long expanse of forested border with Canada.

MIT scientists tried to determine why trees have a different voltage potential than the ground. After eliminating several other possibilities, such as electromagnetic radiation, they unearthed a principle from the 19th century: that pH differences can create a voltage potential.

"Its the imbalance in pH between the inside of the tree and the soil in which it was potted that generates a voltage," said Mershin. "You get about 59 millivolts for every step in pH mismatch."

What is significant about the voltage potential between a tree and its soil, according to Mershin, is that the metabolism of the tree itself works to maintain it; no matter whether its day or night, fall or spring, summer or winter, rain or sun.

"Because the tree has to have a certain concentration of these ions inside of it to be happy about its metabolic and other biological functions, the tree itself actively regulates its own pH. So, no matter what pH soil you put a tree in, it will work hard using its metabolic energy to keep its own pH constant," said Mershin.

The voltage potential is small, but its unflinching continuity means it could be reliably used to trickle-charge a battery or capacitor. This, in turn, can be used to power a wireless sensor node four times a day to transmit data. By implementing a mesh network among the nodes installed on trees, the researchers plan to pass along sensor data from node to node until it reaches a regional weather station. The station would then relay separate sensor readings from individual trees to a central fire-prediction computer.

MIT recently spunoff a company to capitalize on its discoveries about tree power, called Voltree Power (Canton, Mass.) where Mershin is scientific advisor. MIT senior Christopher Love is the vice president for R&D at Voltree. Together, Mershin, Love, Shuguang Zhang, director of MIT's Center for Biomedical Engineering, have been able

to boost the original millivolt-scale potential to over 1 volt, enough to trickle-charge a battery, power a radio and broadcast the output from sensors to a mesh network.

"Voltree has perfected its technique with a proprietary selection of metals for electrodes and an underground electronics box with a spike in it that penetrates the tree at its roots," said Mershin.

A second electrode in surrounding soil supplies a ground for the wireless sensor node electronics. An antenna wire snakes up the tree alongside a wiring harness, connecting the tree-mounted sensor to the underground electronics.

Field testing of the tree-powered wireless sensor network is currently being readied on 10 acres designated by the U.S. Forest Service for spring 2009 trials.

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